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A VARIETY OF MAIZE WITH SILKS MATURING BEFORE THE TASSELS.

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A VARIETY OF MAIZE WITH SILKS MATURING BEFORE THE TASSELS.

INTRODUCTION.

In the varieties of maize cultivated in the United States the anthers usually open before the silks on the same plant appear, and pollen is still falling when the silks are in a receptive condition. Except where high and constant winds prevail at flowering time, this results in a large proportion of self-pollinated seed.

In maize self-pollination so reduces the vigor of the plants that any means by which it can be avoided or reduced is worthy of careful consideration. In nature wind-pollinated species, such as maize, usually avoid self-pollination by producing pollen at a time when the stigmas of the same plant are not in a condition to be pollinated. To have the pollen produced before the stigmas are receptive (proterandry) or the stigmas receptive before the pollen falls (proterogyny) will prevent self-pollination.

Of the two methods proterogyny would appear to be the more advantageous, and is in fact more widespread, though Kerner's statement [1] that "As far as we can tell at present all monœcious plants are protogynous" has been materially modified. According to Hackel,[2] proterandry is more general than proterogyny among the grasses. Of the primitive varieties of maize from tropical America that have been under observation in this country, nearly all are more decidedly proterandrous than the improved varieties grown in the United States.

In spite of the fact that primitive varieties of maize are more often proterandrous than improved varieties, there are reasons for believing that the more remote ancestors of maize were proterogynous. Whether teosinte (*Euchlaena mexicana* Schrad.), the nearest wild relative of maize, is naturally proterandrous or proterogynous, seems not to have been recorded. In our experiments one type of Euchlaena secured from Durango, Mexico, was proterandrous to about the same extent as the unimproved varieties of maize. Samples of

[1] Kerner, A. J., and Oliver, F. W. Natural History of Plants, vol. 2, 1895, p. 313.

[2] Hackel, E. "Gramineæ," in Engler and Prantl, Naturlichen Pflanzenfamilien, Th. 2, Abt. 2, p. 2.

Euchlaena seed from Florida, Costa Rica, and one of unknown origin imported from London produced plants that were all proterogynous. The season was too short, however, for any but the Durango plants to mature seed, and the unusual conditions may have caused the plants to behave abnormally.

It is known that hybrids between maize and teosinte are common in the region about Durango. In fact, seeds that were obviously hybrids between the two species were found in the lot from which our plants were grown. It is therefore possible that although the plants showed nearly all the characters peculiar to Euchlaena, except that they were less branched, they may still be very dilute hybrids with maize, thus accounting for their proterandrous habit. The proterandrous habit in the Durango variety of teosinte is evidently associated with the development of a well-defined main stalk, or culm, a character which it shares with maize and by which it differs from the other types of teosinte.

Aside from the question whether teosinte is naturally proterogynous or not, there is evidence for the belief that the proterandrous habit of maize is the result of the separation of the sexes into different parts of the plant and that the perfect-flowered ancestors of maize were proterogynous.

It is a very common occurrence in maize for pistillate flowers to be developed in the staminate inflorescence as perfect flowers or as scattered pistillate spikelets, or, more often still, for a portion of the inflorescences to be completely pistillate. An example of the frequency with which pistillate flowers occur in the terminal inflorescence of suckers may be seen in the classification of suckers given on page 10. Another abnormality in maize of even more frequent occurrence than pistillate flowers in the staminate inflorescence is for the pistillate inflorescence, or ear, to terminate in a staminate spike.

Whenever male and female flowers occur in the same inflorescence of a maize plant as a result of either of these common abnormalities it has always been observed that the silks are developed some days before the male flowers open. If these abnormalities are looked upon as reversions to a perfect-flowered ancestor it seems reasonable to assume that this primitive ancestor was proterogynous.

ADVANTAGES OF PROTEROGYNY.

Selection for earliness and the crusade against the so-called barren stalks have without doubt operated to change the condition of proterandry that obtains in the unimproved varieties of maize to one of approximate synacme, where pollen and silks appear simultaneously. Synacme is certainly less desirable than proterandry, but now that

we have unwittingly progressed thus far may it not be possible to proceed to the still more desirable condition of proterogyny?

Self-pollination, while less desirable, is at the same time less precarious than cross-pollination. It seems to be an inefficient arrangement to have the opportunity for the deleterious (but relatively more certain) self-pollination precede the opportunity for the advantageous (but more precarious) cross-pollination. If the conditions could be reversed by having the plants moderately proterogynous, the proportion of cross-pollinated seed would be greatly increased, while if by any chance the silks failed to receive foreign pollen, pollen from the same plant would be forthcoming as a last resort, and the danger of poorly filled ears would be avoided.

The advantages of proterogyny in maize appear so important that the effort has been made to develop this habit in some of the improved varieties. Occasional proterogynous plants are to be found in most varieties, and wherever such plants have been observed in our experiments seed has been saved and planted the following year.

In many instances it was found, however, that the proterogyny was only apparent, resulting from an abnormal development of the staminate flowers, and many of the plants noted as proterogynous proved to be sterile as far as the production of pollen was concerned. As with other characters that result from injury or abnormal conditions, proterogynous variations of this nature have been found to be inherited very imperfectly, if at all, and little progress has been made by this method. The discovery of a variety that appears to be regularly proterogynous makes the outlook for improvement in this direction much more hopeful.

Two ears of a red pop corn, purchased at Granada, Spain, by Mr. Walter T. Swingle, of this Bureau, in January, 1912, and planted at Lanham, Md., the following spring, produced plants, nearly every one of which was proterogynous.

The ears of this variety are so small that the variety will probably be of no economic importance except perhaps as a pop corn. The subsequent behavior of the variety can not be safely inferred from its behavior the first year, but that the proterogynous tendency exists to a marked degree seems certain, and to attempt its transfer to our improved varieties would seem well worth the effort. The present account is published in the belief that those interested in developing new types of maize will find valuable breeding material in this strain. Only a small quantity is on hand, but a few seeds can be supplied to those wishing to make a study of this variation and to assist in determining its economic importance.

The improvement of maize varieties should be looked upon as a local problem. The acclimatization of an improved variety is likely to entail nearly as much time and labor as the original work of improve-

ment. Before the value of a variety possessing novel characteristics can be determined it should be tried in a great variety of different conditions and in combination with different varieties.

DESCRIPTION OF THE VARIETY.

The two original ears secured by Mr. Swingle, though apparently belonging to the same general type, showed obvious differences. Ear No. 1 (fig. 1) was 12 cm. long, 13 cm. in circumference, rather abruptly tapering, and with 20 somewhat irregular rows of small, rounded grains. The pericarp was wine colored or garnet. A few of the seeds of this ear had a colored aleurone visible beneath the colored pericarp. The stigmas were persistent after the manner of the "rice" varieties, but the seeds were not beaked. The cob was a dirty red. Ear No. 2 (fig. 2) was 16 cm. long, 10.5 cm. in circumference, more nearly cylindrical, and with 16 regular rows. The pericarp was much lighter than in ear No. 1, almost a brick red. The stigmatic point was apparent, but no portion of the stigma remained attached to the seed. The cob was colored, but was of a lighter shade than that of ear No. 1.

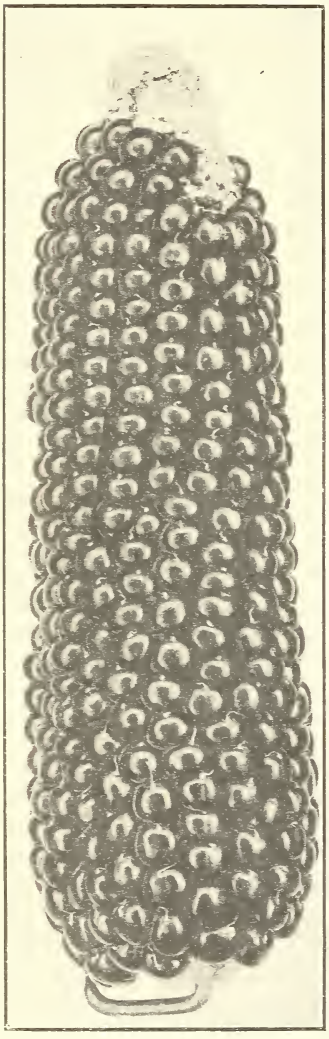

FIG. 1.—Proterogynous variety of maize. Ear No. 1. (Natural size.)

Ears Nos. 1 and 2 have been numbered 34426 and 34427, respectively, in the seed and plant introduction series of the Department of Agriculture.

Seeds from each of the ears were planted in separate rows and 62 plants grew to maturity. The plants were strong, vigorous, and unusually uniform (fig. 3). Aside from the proterogynous habit, the most striking characteristic of the type was the dense clustering of the spikelets toward the end of the branches of the tassel. To make possible a quantitative statement of this tendency, the uppermost branch of the tassel of each plant was divided at the middle and the spikelets of the two halves counted. It was found that on the average

the distal half of the branch bore 2.13 times as many spikelets as the proximal half.

It was in connection with this variety that this character was first noted, and consequently the data for making comparisons with other varieties are meager. Measurements of 50 plants taken at random from a neighboring field of Boone County White corn showed the distal portion to have only 1.33 times as many spikelets as the proximal portion. In other varieties the distribution of the spikelets is still more nearly uniform.

The increase in the number of the spikelets toward the end of the branches is brought about by a change in the arrangement. In the basal portion of the branches the arrangement is normal, that is, the spikelets are arranged alternately in pairs, each of which consists of a stalked and a sessile spikelet. Toward the end of the branches all the spikelets are sessile and the number in each group increases from two to three or more.

Another peculiarity, perhaps associated with the proterogynous habit, is that the silks in most of the plants, instead of appearing first on the uppermost ear, appear almost simultaneously from three ears, and in a number of plants the silks of the second ear showed before those of the first ear.

Daily notes were taken on the individual plants, and the flowering time of both male and female flowers was noted. Of 59 plants, 8 had sterile tassels and failed to produce pollen. Of the remaining 51 plants, in 1 the anthers opened two days before the

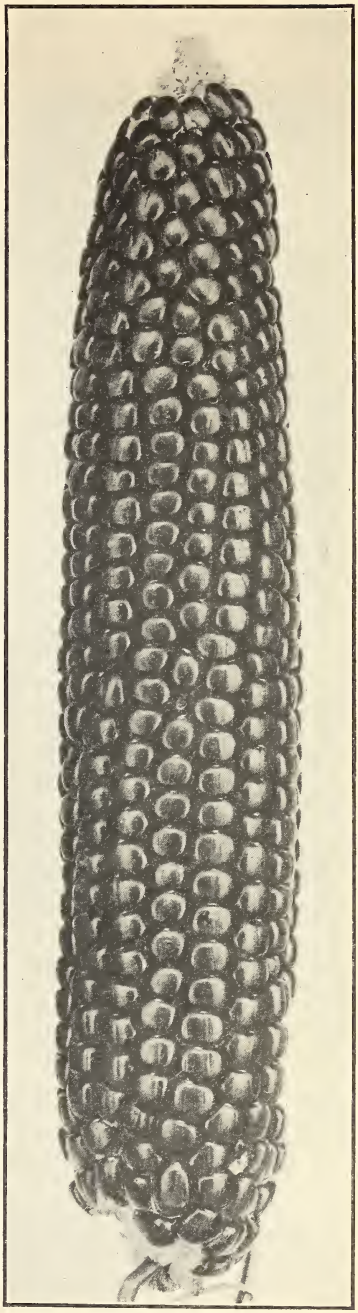

FIG. 2.—Proterogynous variety of maize. Ear No. 2. (Natural size.)

silks emerged, in 9 the silks appeared on the day the first pollen was shed, and in 41 silks were produced from 1 to 7

FIG. 3.—Plant of a proterogynous variety of maize.

days before pollen fell. The average number of days that elapsed after the silks emerged before pollen was shed was 2.1. The rela-

tive frequency of the different degrees of proterogyny is shown below:

Number of days after the silks appeared before pollen was shed	−2	−1	0	1	2	3	4	5	6	7
Number of plants	1	0	9	7	13	13	5	2	0	1

Of the 29 plants grown from ear No. 1, the pericarps of 9 were white, the remaining 20 being colored as in the parent ear. Of the 33 plants grown from ear No. 2, the pericarps of 11 were white, the remaining 22 being a red of the same shade as the parent ear and consistently lighter than the progeny of ear No. 1.

The measurements shown in Table I are given with the idea of providing data for determining the effects of acclimatization. The size of a plant and of its various organs is so directly dependent on the nature of the environment that measurements are of little value for descriptive purposes except as they are made comparative by including familiar varieties that may be used as a standard. If, however, the expression of characters has been seriously disturbed by the change of locality, the number of the different parts as well as the actual dimensions may be expected to change in subsequent generations, and the data here presented may serve as a rough indication of such comparative relations. Since in a number of characters the differences appear to be significant and not the result of chance variation, the average measurements of the plants grown from each of the two ears as well as the combined averages are recorded separately.

TABLE I.—*Measurements of plants grown from two ears of red pop corn from Spain.*

Character.	Ear No. 1.	Ear No. 2.	Combined average.
Height, centimeters	249 ±3.55	226.5 ±2.57	238.5 ±2.34
Number of nodes above the ground	15.4 ± .12	14.3 ± .12	14.8 ± .07
Number of nodes above the ear	4.93± .08	4.26± .1	4.6 ± .07
Number of green leaves at silking	14.5 ± .16	13.8 ± .09	14.1 ± .09
Length of longest leaf, centimeters	99.8 ±1.14	94.6 ± .88	97.4 ± .75
Width of longest leaf, do	10.1 ± .13	9.6 ± .09	9.8 ± .07
Number of nodes above longest leaf	10 ± .16	9.2 ± .13	9.6 ± .11
Distance from top of last leaf sheath to the lowest tassel branch, centimeters	3.55± .38	3.2 ± .31	3.4 ± .25
Distance from first to last tassel branch, do	13.8 ± .29	15 ± .31	14.2 ± .22
Distance from last tassel branch to tip of tassel, do	29.9 ± .48	27.9 ± .36	29 ± .30
Number of tassel branches	21.6 ± .63	26.6 ± .76	23.9 ± .59
Number of secondary branches in tassel	6 ± .39	7.4 ± .48	6.5 ± .30
Length of uppermost tassel branch, centimeters	.....	18.2 ± .17	.....
Number of spikelets on uppermost tassel branch	.....	82.8 ±2.32	.....
Length of staminate spikelets, millimeters	9.68± .16	9.78± .16	9.73± .07
Number of ears per plant	2.5 ± .08	2.8 ± .14	2.7 ± .13
Number of rows in upper ear	18.3 ± .19	15.8 ± .16	16.2 ± .13
Number of rows in second ear	19.4 ± .42	17.3 ± .27	18.8 ± .24
Length of upper ear, centimeters	19.3 ± .46	18 ± .37	18.6 ± .23
Number of suckers per plant	1.6 ± .19	2.1 ± .18	1.8 ± .10

ABNORMALITIES.

The nature and relationships of a variety are often best determined by a study of the abnormalities which the plants exhibit. Though usually more pronounced the first year that a variety is grown in a new locality, the relative frequency of the different abnormalities is often significant.

The following abnormalities were observed in the plants grown from both ears: Husks coalesced, 2; fascicled spikelets in tassel, 3; lobed husks, 5; ears with staminate flowers at tip, 4; fasciated (or "bear's-foot") ears, 9; ears exserted beyond husks, 4.

In addition to these common abnormalities that occur with varying frequency in nearly all varieties, single examples of the following were discovered: A leaflike bract in the tassel; a small ear inclosed in husks at the base of the tassel; perfect flowers in the ear (in this plant three well-defined stamens were found at the base of nearly every seed—an abnormality which may have been overlooked in other plants, since the presence of less well-developed stamens could have been determined only by carefully dissecting each ear); two seeds grown together in the ear;[1] and a secondary ear borne directly in the axil of the prophyllum instead of the axil of a husk, a phenomenon of rare occurrence in maize, except in the hairy Mexican type (*Zea hirta*), in which it is normal.

The above abnormalities were confined to 21 plants. In the remaining 38 plants no abnormalities were observed.

Great diversity was exhibited in the suckers, a characteristic of unimproved types, especially when grown in a new locality. The series was so extensive that an attempt was made to classify the different types, the result of which is shown in Table II, together with the relative frequency of the different types. These variations might be classed as abnormalities, but they all represent intermediate stages between the two normal types of branches, viz, the pistillate inflorescence (or ears) and normal suckers that are replicas of the main stalk.

TABLE II.—*Classification of suckers.*

No.	Description of sucker.	Number of plants.
1	Resembling main stalk, ear and tassel normal	17
2	Similar to No. 1, with no ear developed	20
3	Terminal inflorescence staminate, with tips of central spike and branches aborted; no ear	4
4	Similar to No. 3, with ear in normal position	1
5	Terminal inflorescence staminate, with scattered pistillate flowers on both central spike and branches; no ear	1
6	Similar to No. 5, with ear in normal position	1
7	Terminal inflorescence staminate and normal except for one pistillate branch; no ear	1
8	Terminal inflorescence staminate and normal except for a pistillate portion at tip of central spike; no ear	11
9	Similar to No. 8, but with ear in normal position	1
10	Terminal inflorescence staminate except for a pistillate portion at the base of both central spike and branches; no ear	3

[1] This abnormality has been described and its significance discussed by Mr. J. H. Kempton in "Two-Flowered Female Spikelets in Maize," Bulletin 278 of the Bureau of Plant Industry.

TABLE II.—*Classification of suckers*—Continued.

No.	Description of sucker.	Number of plants.
11	Terminal inflorescence staminate except for a pistillate portion at base of central spike and tips of branches; no ear	4
12	Terminal inflorescence staminate, with pistillate portion at base of central spike; branches wanting; no ear	1
13	Terminal inflorescence with pistillate portions at the base and tip of central spike; branches staminate; no ear	1
14	Terminal inflorescence with central spike completely pistillate; branches staminate, or nearly so; no ear	5
15	Similar to No. 14 except for a staminate portion at tip of central spike	1
16	Terminal inflorescence with central spike completely pistillate; branches staminate, with pistillate portion at tip; no ear	5
17	Terminal inflorescence with central spike completely pistillate; branches pistillate, or nearly so; no ear	2
18	Terminal inflorescence pistillate; no branches; no ear	5
19	Terminal inflorescence a normal staminate tassel, with an ear at its base; no ear in normal position	3
20	No terminal inflorescence; no ear	1

The suckers which resembled main stalks, producing both ears and tassels, were also for the most part proterogynous, though less uniformly so than the main stalk. Notes were secured on the suckers of 15 such plants. Of these, two were proterandrous, one was synacmic, two had one sucker proterogynous and one proterandrous, four had sterile tassels, and eight were proterogynous. In every plant with sterile tassels on the sucker the tassel of the main stalk was also sterile. There were apparently no intermediate stages between completely sterile tassels and those producing an abundance of pollen. Sterile tassels are not uncommon in many varieties of maize which show no proterogynous tendencies.

SUMMARY.

The present paper records the discovery of the proterogynous habit in a variety of maize introduced from Granada, Spain. In plants of this type the silks are exserted and receptive before the pollen begins to fall. This proterogynous characteristic insures a much larger percentage of cross-pollinated seed than is obtained in the ordinary varieties, in which the falling of the pollen is simultaneous with or precedes the exsertion of the silks. If this character can be combined with the good qualities of improved American types it will obviate the necessity of detasseling to secure cross-pollinated seed.

A small quantity of pure seed of this variety was produced during the past season and is available for those wishing to undertake the introduction of this character into local varieties.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *November 21, 1912.*

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